1 358 985

PATENT SPECIFICATION

(11) 1 358 985

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(19)

(54) ARC WELDING

(71) We, THE BRITISH OXYGEN COMPANY LIMITED, an English company, of Hammersmith House, London W6, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to arc welding using a consumable metal electrode with the arc shielded by a gas supplied from an external source.

It is usual in such welding to connect the welding power source so that the polarity of the electrode is positive with respect to the workpiece. Employing an electrode whose polarity is negative with respect to the workpiece is theoretically attractive because with mild steel electrodes the voltage drop at a cathode is greater than that at an anode. This should result in an increased welding speed, due to increased metal deposition, for a given welding current, leading to more economical welding. However the use of electrode negative welding has attendant disadvantages. These are primarily that the arc becomes very unstable, and that the transfer of weld metal to the workpiece is coarse, erratic and non-axial, giving rise to an unacceptable amount of weld spatter.

The present invention aims at providing a gas-shielded, arc welding process with a consumable electrode, in which the amount of spatter is small.

Accordingly the present invention provides a method of arc welding as claimed in the appended claims.

By 'globule' in this specification is meant the molten part of the consumable electrode before it comes into contact with the workpiece. Also in this specification, the term 'shielding gas' is to be taken to include a mixture of gases.

The present invention will now be described in greater detail by way of example with reference to the accompanying drawing, in which:—

Figure 1 is a diagrammatic side view of arc welding apparatus with the electrode negative;

Figure 2 shows successive views of the formation of a detached weld globule by carrying out the teachings of the present invention;

Figure 3 shows curves relating the quality of the weld bead produced by the present invention, for different mixtures of argon, carbon dioxide and oxygen;

Figure 4 relates the quality of fillet welds obtained on stainless steel with different compositions of shielding gas, and

Figure 5 is similar to Fig. 4, relating the quality of any welds on stainless steel with an argon-rich shielding gas containing hydrogen.

In the apparatus shown in Figure 1, a contact tip 2 is connected to the negative terminal of a suitable source of welding current. The source would be adapted to supply up to about 500 A at a voltage of up to about 48 V, although the maxima are rarely, if ever, used simultaneously.

The contact tip 2 has the consumable electrode fed through it and in contact with it so that the electrode is at the potential of the contact tip.

Spaced from the end of the consumable electrode is a workpiece 6, in this case shown as two abutting plates of mild steel. The action of the arc welding process is to produce a molten pool 8 in the upper surface of the workpiece, into which molten pool successive globules of molten electrode material are deposited by the arc struck between the adjacent end of the electrode 4 and the workpiece.

For clarity, the means by which the arc is struck are omitted from the drawing, as they do not in themselves form part of the subject-matter of the present invention.

When the shielding gas consists predomi-

nantly of argon with a small percentage of oxygen, it has been found that the arc is relatively stable but that it is too long; it is very difficult for the operator to exert any effective control over the welding process, and the weld bead tends to be undercut. In addition the arc is so bright that it tends to obscure the weld bead from the view of the operator.

When a shielding gas of pure argon is used, it has been found that the arc root tends to move back up the unmolten part of the electrode until it reaches the contact tip, after which it restrikes to the molten globule and produces a hot spot on the globule at a random location. The electromagnetic forces produced by the arc tend to act on the globule so that when it is massive enough to become detached from the electrode the non-axial electromagnetic forces tend to cause the globule to move transversely to the electrode axis so that it becomes deposited on the workpiece at random locations spaced from the desired molten pool, giving rise to very poor welding with an excessive amount of spatter.

When helium is added to the argon there is a higher frequency of oscillation of the arc root along the length of the electrode, and for a lesser distance than with pure argon but, as the arc also tends to extinguish itself, the gas composition is not acceptable.

In accordance with the present invention it has been found that it is possible to choose a specific combination for the shielding gas which overcomes, as least partially, the problem of weld spatter.

The composition of the gas can be varied over a relatively restricted range, but it is thought that particular compositions are best chosen empirically for different applications, although it is hoped that 'universal' gas mixtures can be arrived at which give acceptable electrode-negative arc welding under a wide range of welding conditions.

By 'electrode negative welding' in this specification is meant welding in which the polarity of the consumable electrode is negative with respect to the workpiece throughout each welding cycle.

In accordance with the present invention it has been found that when there is used for electrode negative arc welding a shielding gas comprising of 2 to 20% by volume of carbon dioxide; from 0.5 to 4% by volume of oxygen and from 70 to 97.5% by volume of argon then the amount of spatter can be considerably reduced. The percentage of carbon dioxide present may advantageously be from 4 to 18% by volume, eg from 6 to 15%, say 12%.

When the work piece is of stainless steel the shielding gas preferably comprises from 3 to 15%, most preferably 5 to 10%, by volume of carbon dioxide; from 1 to 4% by volume of oxygen and from 75 to 96% most preferably 82 to 91%, by volume of argon. With stainless work pieces the shielding gas also advantageously comprises hydrogen, preferably in a proportion of from 1 to 6% by volume. In such cases it will often be desirable to employ from 2 to 15%, say substantially 6% by volume of carbon dioxide.

It has been found that when shielding gas mixtures as aforesaid are used, the weld globule tends to divide itself automatically into two or more parts each connected by a neck portion of reduced cross-sectional area. Both portions of the globule tend to carry welding current, each being connected electrically to the work piece through the arc plasma, so that the partially detached weld globule carries only a proportion of the welding current. This flow of current tends to give rise in the neck portion to a relatively high current densities which produce electro-magnetic forces tending to act on the neck to reduce its cross section still further.

This process continues automatically until the neck is ruptured to produce a detached globule. The forces acting on this globule by the arc which remains struck between the electrode and the undetached globule have virtually no transverse components so that the detached globule tends to fall, or be propelled, directly at the subjacentportion of the workpiece, which is of course the molten pool 8.

As the arc is relatively stable, and remains struck between the solid electrode and the attached globule, the electrode continues to be fused to cause the globule to grow successively larger until it again divides into two parts connected by a neck portion, and the cycle is repeated.

It will be appreciated that the mode of operation of the welding process is largely theoretical, and the applicants do not wish to limit themselves to any particular theory of operation.

Figures 2A—2C show successive stages in the formation of a detached globule of fused electrode, starting from the electrode having a small attached globule.

The outer curve in Fig. 3 represents the composition of different gas mixtures giving rise to weld beads of acceptable quality, while the inner curves relates to weld beads of desirable quality. These estimates have to be subjective, but it is believed that most experts in this part of welding technology would agree substantially with the estimates of bead quality.

Fig. 3 was obtained when welding mild steel.

The curves of Fig. 4 were obtained with fillet welds on stainless steel using 1.2 mm diameter stainless steel wire. This was fed at 12.7 m min $^{-1}$ and was supplied with a welding current of 250A at 24.5 V, direct.

It will be seen that some satisfactory welds

were obtained with no oxygen or no carbon dioxide in the shielding gas, but that optimum values require both gases to be present.

The curves of Fig. 5 were obtained with argon-rich shielding gases containing 1.5—3.2% of hydrogen in addition to the indicated values of oxygen and carbon dioxide. The difficulty of showing varying effects of three components in the gas mixture in a two-dimensional graph will be appreciated, but it is thought that the presence of small amounts of hydrogen is significant for stainless steel welding, and not just fillet welding.

The welding conditions for Fig. 5 are similar to those for Fig. 4, except that the welding voltage was in the range 24—31 V.

WHAT WE CLAIM IS:—

1. A method of arc welding using a consumable electrode and an externally supplied shielding gas, in which the polarity of the electrode is negative with respect to the work-which the shielding gas comprises from 2 to which the shielding gas comprises from 2 to 20% by volume of carbon dioxide, from 0.5 to 4% by volume of oxygen and from 70 to 97.5% by volume of argon.

2. A method according to claim 1 wherein the percentage of carbon dioxide is from 4 to 18%.

3. A method according to claim 2 wherein the percentage of carbon dioxide is from 6 to 15%.

4. A method according to claim 1 wherein the workpiece is of mild steel and the proportions of oxygen and carbon dioxide in the shielding gas lie within the area enclosed by the outer graph of figure 3 of the accompanying drawings.

5. A method according to claim 1 wherein the workpiece is of stainless steel and the shielding gas comprises from 3 to 15% by volume of carbon dioxide, from, 1 to 4% by volume of oxygen and from 75 to 96% by volume of argon.

6. A method according to claim 5 wherein the shielding gas contains 5 to 10% by volume of carbon dioxide.

7. A method according to claims 1, 5 and 6 wherein the shielding gas further comprises hydrogen.

8. A method according to claim 7 wherein the shielding gas comprises not less than 4% by volume of carbon dioxide and from 1 to 4% by volume of hydrogen.

9. A method according to claim 8 wherein the shielding gas comprises from 5 to 10% volume of carbon dioxide.

10. A method according to claim 9 wherein the shielding gas comprises substantially 6% by volume of carbon dioxide.

11. A method according to claim 7 wherein the shielding gas comprises from 2 to 15% carbon dioxide; up to 4% by volume of oxygen and from 1 to 6% by volume of hydrogen.

12. A method according to claim 4 wherein the proportions of oxygen and carbon dioxide in the shielding gas lie within the smaller area of the graph shown in Fig. 3 of the accompanying drawings.

For the Applicants,
K. B. WEATHERALD.

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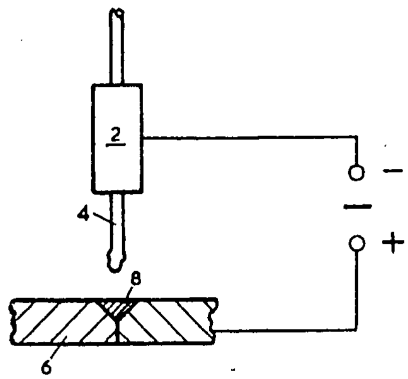

FIG.1

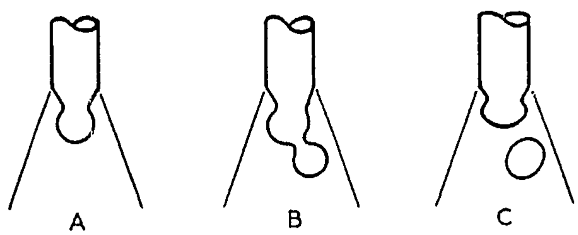

FIG.2

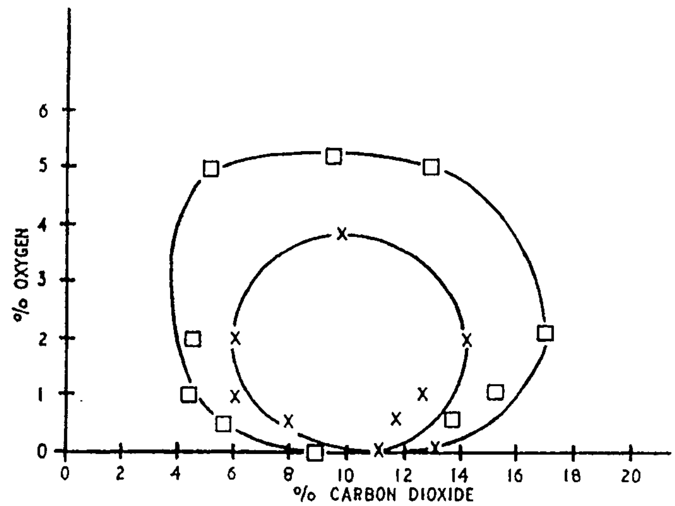
% OXYGEN
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
% CARBON DIOXIDE

FIG.3

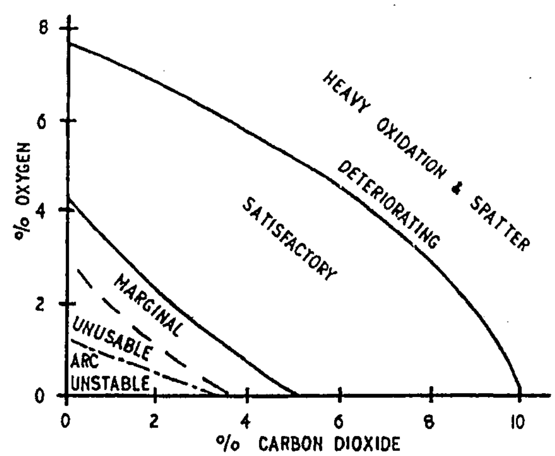
% OXYGEN
0
2
4
6
8
0
2
4
6
8
10
% CARBON DIOXIDE
HEAVY OXIDATION & SPATTER
DETERIORATING
SATISFACTORY
MARGINAL
UNUSABLE
ARC
UNSTABLE

FIG.4

1358985 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

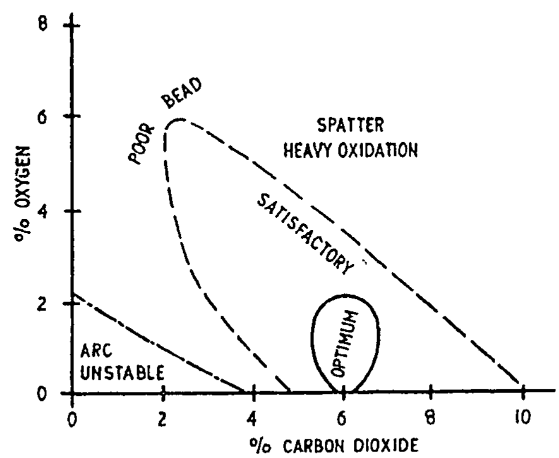

FIG. 5